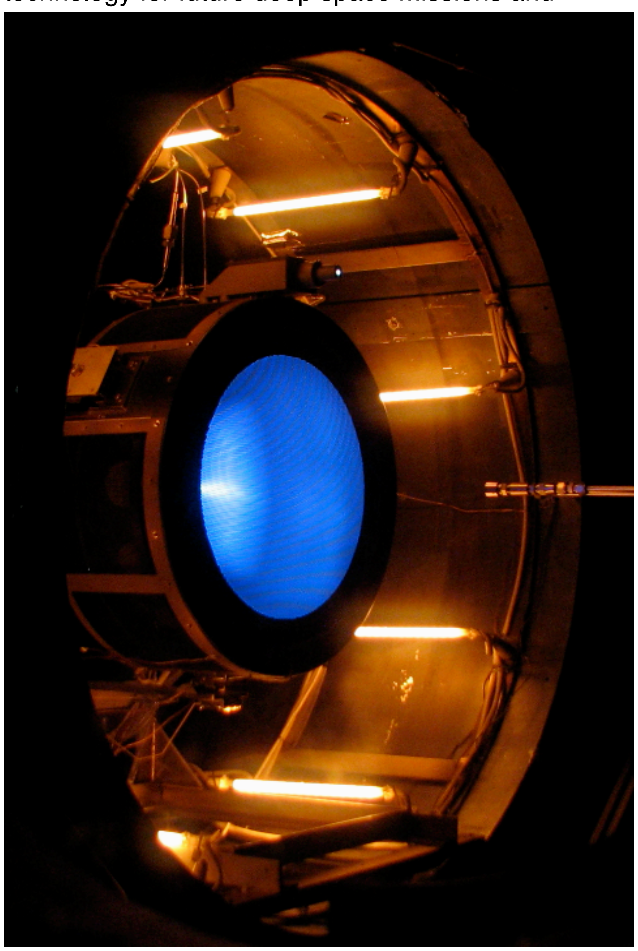
Advanced Electric Propulsion

In-Space Propulsion Technology Project

NASAfacts

As NASA's Science Mission Directorate progresses its robotic missions from observers to rovers to sample return missions, the demanding goals exceed the capabilities of conventional propulsion technologies and will ultimately require improved spacecraft capabilities such as those obtained from advanced electric propulsion technologies. The In-Space Propulsion Technology Project is maturing advanced electric propulsion technology product lines for near-term flight infusion opportunities, including advanced ion and hall propulsion systems.

In the early 1990s, NASA identified electric propulsion as a key in-space propulsion technology for future deep space missions and began developing and testing various electric propulsion technologies. Intended to reduce fuel mass, decrease travel times and permit larger payloads, electric propulsion technologies may be one of the keys to our continued exploration of Earth's neighboring worlds. Electric propulsion technologies generate thrust via electrical energy. This energy is used to accelerate an on-board propellant such as xenon gas.



NASA's Evolutionary Xenon Thruster (NEXT) during environmental testing at NASA's Jet Propulsion Laboratory.

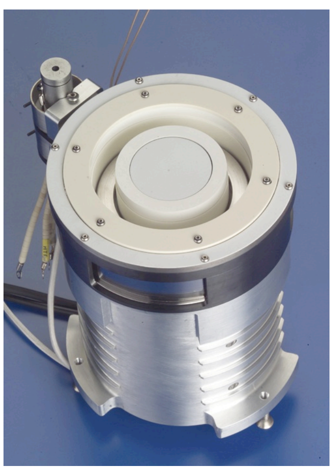
Spacecraft powered by typical electric propulsion systems may eject propellant at up to 20 times the speed of conventional chemical systems, delivering a much higher specific impulse, or in other words more thrust from the weight of fuel consumed. Therefore, electric-based systems require far less propellant mass than a state-of-art, chemical-propellant craft. Another benefit of electric propulsion is that deep-space missions would no longer be constrained by narrow and rare launch window opportunities dictated by planetary alignment. Traditionally, chemical-propelled spacecraft move from planet to planet as they travel, using "gravity-assist" maneuvers in each world's orbit to increase their own velocity and "sling-shot" toward their final destination.

NASA's Evolutionary Xenon Thruster (NEXT) Ion Propulsion System nears TRL-6:

The NEXT system consists of a high-performance, 7-kW ion thruster; a high-efficiency, 7-kW power processor unit (PPU); a highly flexible xenon propellant management system (PMS); a lightweight engine gimbal; and key elements of a digital control interface unit (DCIU) including software algorithms. A Long-Duration Test (LDT) was initiated to validate and qualify the NEXT propellant throughput capability to a qualification-level of 450 kg, 1.5 times the mission-derived throughput requirement of 300 kg, and to demonstrate the life-limit of the thruster. The LDT has exceeded 800 kg in January 2013. The NEXT Prototype Model (PM) ion thruster has passed qualification-level environmental tests. The NEXT Engineering Model (EM) PPU has completed a round of functionality tests and is being prepared for environmental tests. The NEXT PMS has completed all environmental tests. Recent activities include a single-string integration test of the PM thruster the EM PPU and the EM PMS and continuation of the EM thruster life validation test. In addition ISPT is implementing tasks, which will address first-user costs for electric propulsion systems, such as reducing life qualification costs.

Table 1. Performance Summary of NEXT and SOA Ion (NSTAR).

Characteristic	NEXT	SOA Ion
Thruster Power Range, kW	0.5-6.9	0.5-2.3
Throttle Ratio	> 12:1	4:1
Max. Specific Impulse, sec	>4100	>3100
Max. Thrust, mN	236	92
Max. Thruster Efficiency	>70%	>61%
Max. PPU Efficiency	94%	92%
Propellant Throughput, kg	>530	157
Specific Mass, kg/kW	1.8	3.6
PPU Specific Mass, kg/kW	4.8	6.0
PMS Single-String Mass, kg	5.0	11.4
PMS Unusable Propellant Residual	1.00%	2.40%



High Voltage Hall Accelerator (HIVHAC) Thruster - Hall Thruster:

The recent focus of the HIVHAC thruster task has been to develop a 3.6 kW Hall thruster with increased specific impulse, throttle-ability and lifetime to make Hall propulsion systems available for deep space science missions. The primary application focus for the resulting Hall propulsion system would be cost-capped missions, such as Discovery-class missions. This is another way that ISPT is addressing first-user costs of electric propulsion systems. The thruster has processed in excess of 100 kg of xenon throughput at a discharge voltage of 700 volts, and is on track to demonstrate the predicted thruster life. At 3.5 kW the thruster has demonstrated a performance of 62% total efficiency and 2700 seconds total impulse, and a predicted lifetime exceeding 15,000 hours. Plans are underway for the design, fabrication, and build of an engineering model thruster that can provide predicted thruster performance across the anticipated environmental conditions.

Table 2: Performance Summary of HIVHAC and SOA Hall (SPT-100).

Characteristic	HIVHAC	SOA Hall
Thruster Power Range, kW	0.3 - 3.9	1.4
Throttle Ratio	12:1	1:1
Operating Voltage, V	200 – 700	300
Specific Impulse, s	860 – 2700	1450
Thrust, mN	20 – 207	79.8
Thruster Alpha, kg/kW	2.5	4
Propellant Throughput, kg	300	150

NASA's Electric Propulsion team includes researchers from Glenn Research Center in Cleveland; the Jet Propulsion Laboratory in Pasadena, California; and leading-edge partners in other government agencies, industry and academia. The Glenn Research Center manages the In-Space Propulsion Technology Project for the Science Mission Directorate in Washington. For more information about NASA In-Space Propulsion Technology systems, visit:

For more information about NASA's In-Space Propulsion program and electric propulsion, visit: is http://spaceflightsystems.grc.nasa.gov/SSPO/ISPTProg/

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